REPORT NO 4-95

EVALUATION OF BAUER K-22.0 HIGH PRESSURE BREATHING AIR COMPRESSOR

GEORGE D. SULLIVAN

April 1994

NAVY EXPERIMENTAL DIVING UNIT

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
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PANAMA CITY, FLORIDA 32407-7015

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Approved for public release; distribution unlimited

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

In response to NAVSEA tasking, Navy Experimental Diving Unit (NEDU) evaluated the BAUER K-22.0 High Pressure Breathing Air Compressor from 17 March to 30 March 1994. The BAUER K-22.0, when operating at 5000 PSI, met Navy diving community requirements making it suitable for recommendation for the Approved for Navy Use List published by NAVSEA 00C, provided cadmium plated fittings are replaced.

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I. INTRODUCTION

In response to NAVSEA tasking[1-2] , a BAUER HIGH PRESSURE AIR COMPRESSOR, MODEL K22.0, ELECTRIC DRIVE was re-tested[3] by the Navy Experimental Diving Unit (NEDU). This compressor system was previously tested and recommended for approval at 211 bars (3000 psi), (see NEDU Report 6-90)[4]. The purpose of this 25 hour test[3] was to evaluate the P-10 purification system, to upgrade the compressor pressure rating from 207 bars (3000 psi) to 344 bars (5000 psi) and to:

a. Determine if the compressor and Purification System provides compressed air at the required pressures, flow rates, quality and cleanliness required by the U.S. Navy[5].

b. Determine the adequacy of the manufacturer's information, instructions and guidance for the safe operation and overall management of the compressor.

c. Ensure that the compressor purification system discharged clean breathing air required by the U.S. Navy[5].

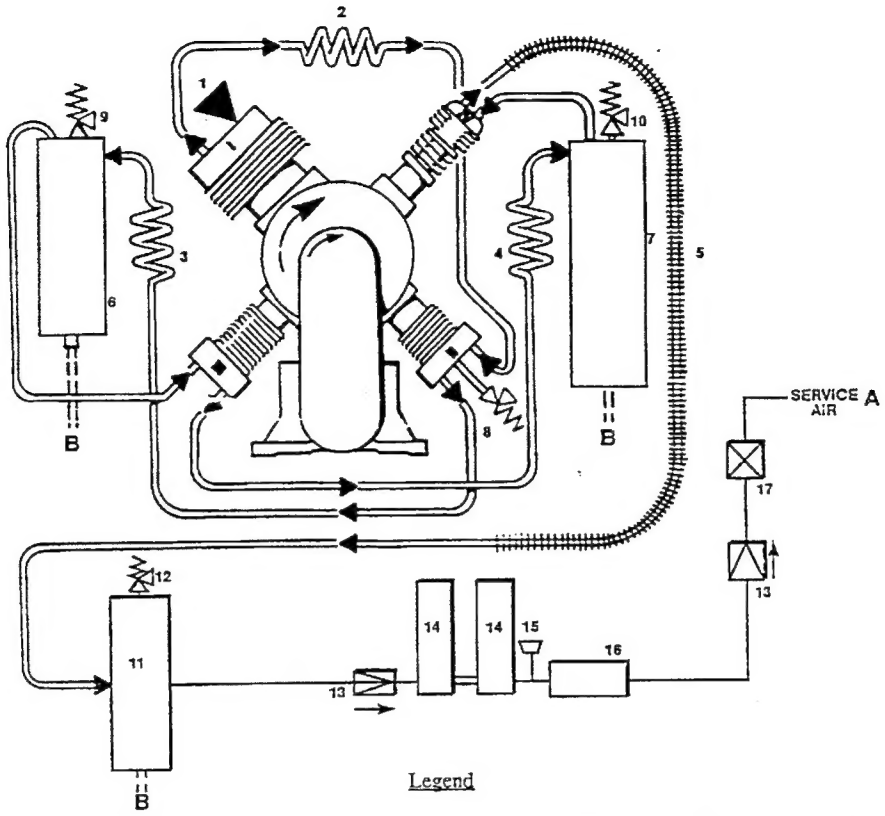
II. EQUIPMENT DESCRIPTION

A. GENERAL

The BAUER, MODEL K22.0 high pressure, breathing air compressor (Figure 1 thru 4) is a four stage, three cylinder, "W" configuration. The 1st and 2nd stages are housed in one common stepped cylinder. All first, second, and fourth stage cylinders are forced oil lubricated via an oil pump and oil pressure regulator. The third stage cylinder is splashed-lubricated (Figure 5). The compressor requires approximately 8 liters (8.5 quarts or 2.1 U.S. gal.) of lubricating oil.

The BAUER compressor unit consists of a compressor block, P-10 purification system, auto drain monitoring system, and a drive motor mounted in a compressor module. The drive unit for this test was a 460 Volt, 3 Phase, 25 Horsepower motor. It is equipped with a slide type motor plate and V-belt pulley. Rotational torque is transferred to the compressor by three V-belts. Electric motors purchased for use with this compressor shall comply with Navy standards for sealed insulation units[6].

The interstage separators are installed after the 2nd and 3rd stages. A sintered filter element is provided in the interfilter after the 2nd stage to eliminate solid contaminants. Water and oil are separated after the 4th stage. Elimination of all liquid oil and water particles in the 3rd and 4th stages is performed by the centrifugal action of a helical insert. The internal operation of the 2nd stage interfilter separators is through a vortex plate. The interfilter and oil and water separator are automatic, draining through a muffler/reservoir system. The auto drain



Legend

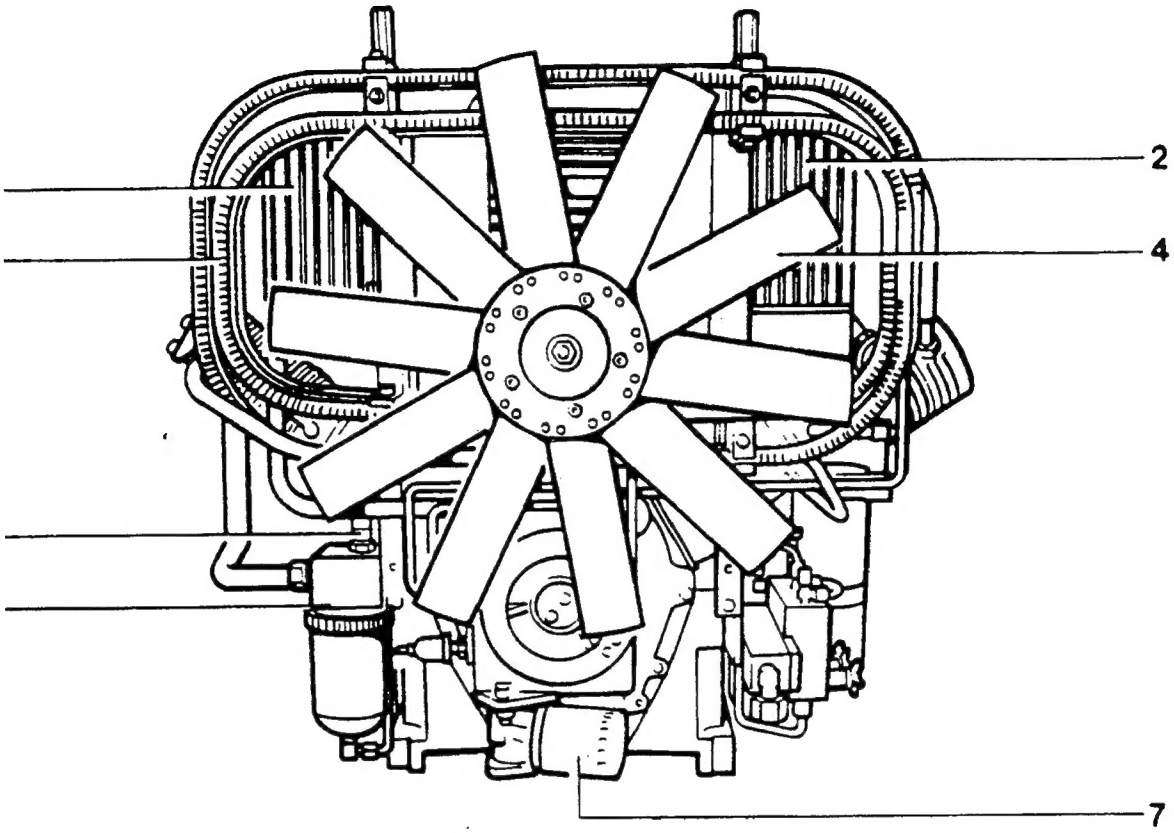
1. Intake Filter
2. Intercooler (1st stage)
3. Intercooler (2nd stage)
4. Intercooler (3rd stage)
5. After Cooler
6. Condensate Block (2nd/3rd stage)
7. Interfilter (3rd/4th stage)
8. Interm. Pressure Safety Valve (1st stage)
9. Interm. Pressure Safety Valve (2nd stage)
10. Interm. Pressure Safety Valve (3rd stage)
11. Condensate Block (4th stage)
12. Final Pressure Relief
13. One-Way Valve
14. Filters
15. Bleed Off Valve
16. Pressure Maintaining Valve
17. Service Valve

A Air Outlet

B Condensate Outlet

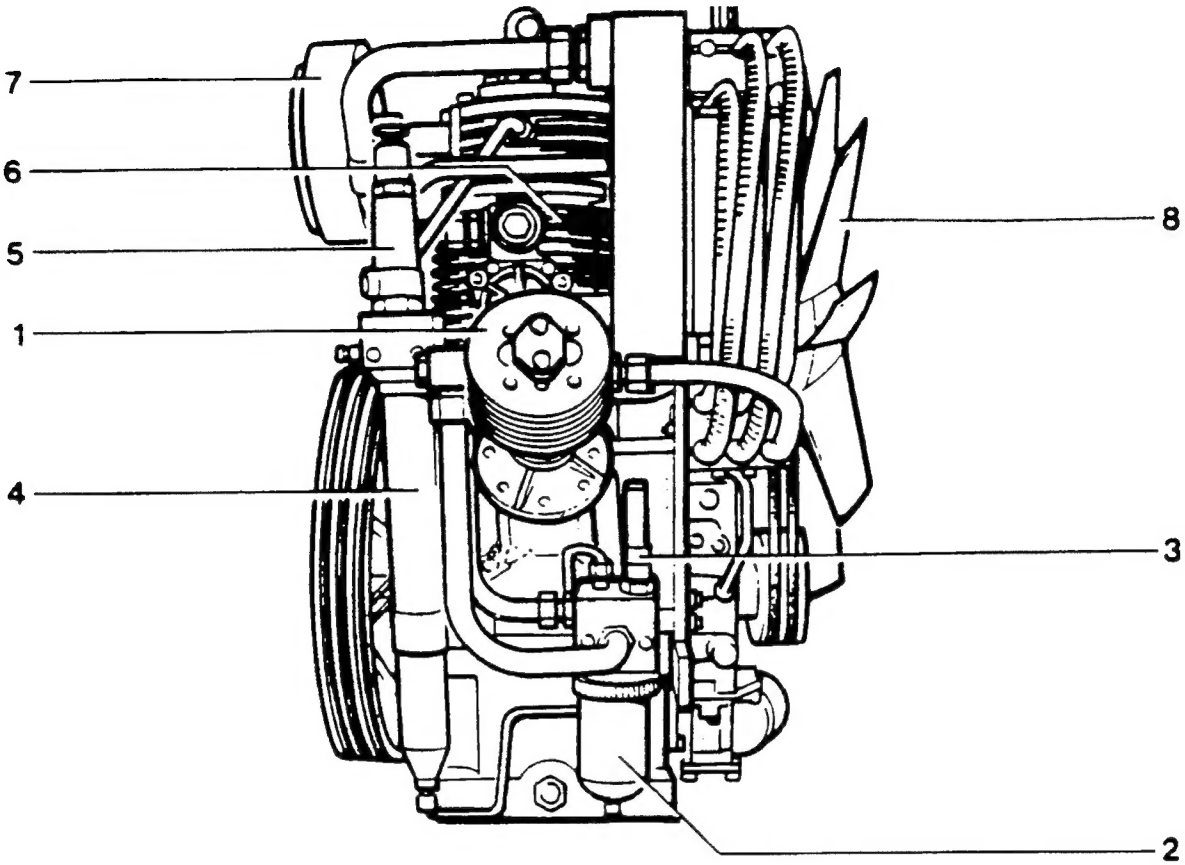
Note: Condensate Blocks 6, 7, and 11 are actually mounted on a heated condensate drain manifold along with the final separator.

Figure 1 Model K22.0 High Pressure Air Compressor
Front View (Flywheel Side)



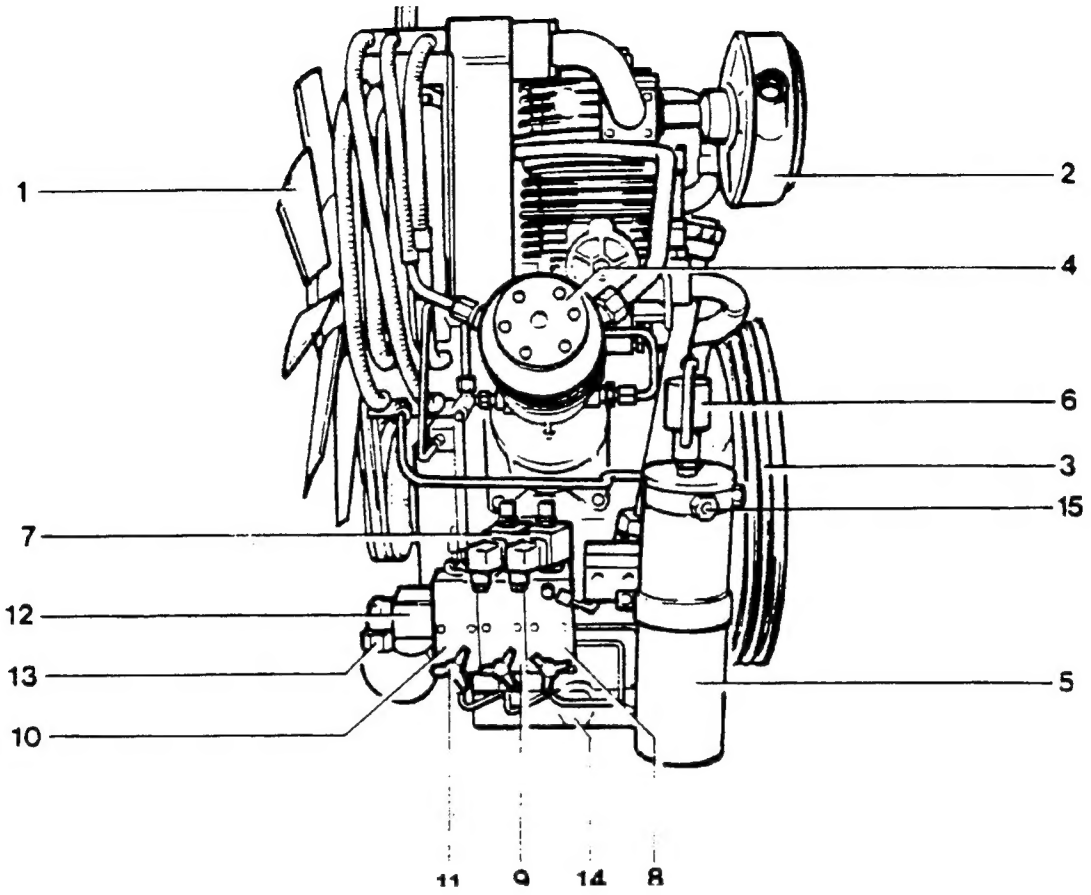
1 Inter-cooler 1st/2nd stage
2 Inter-cooler 2nd/3rd stage
3 Inter-cooler 3rd/4th stage and after-cooler
4 Fan-wheel
5 Safety valve, 2nd/3rd stage
6 Inter-filter 2nd/3rd stage
7 Oil filter

Figure 2 Model K22.0 High Pressure Air Compressor
Rear View (Fan-Wheel Side)



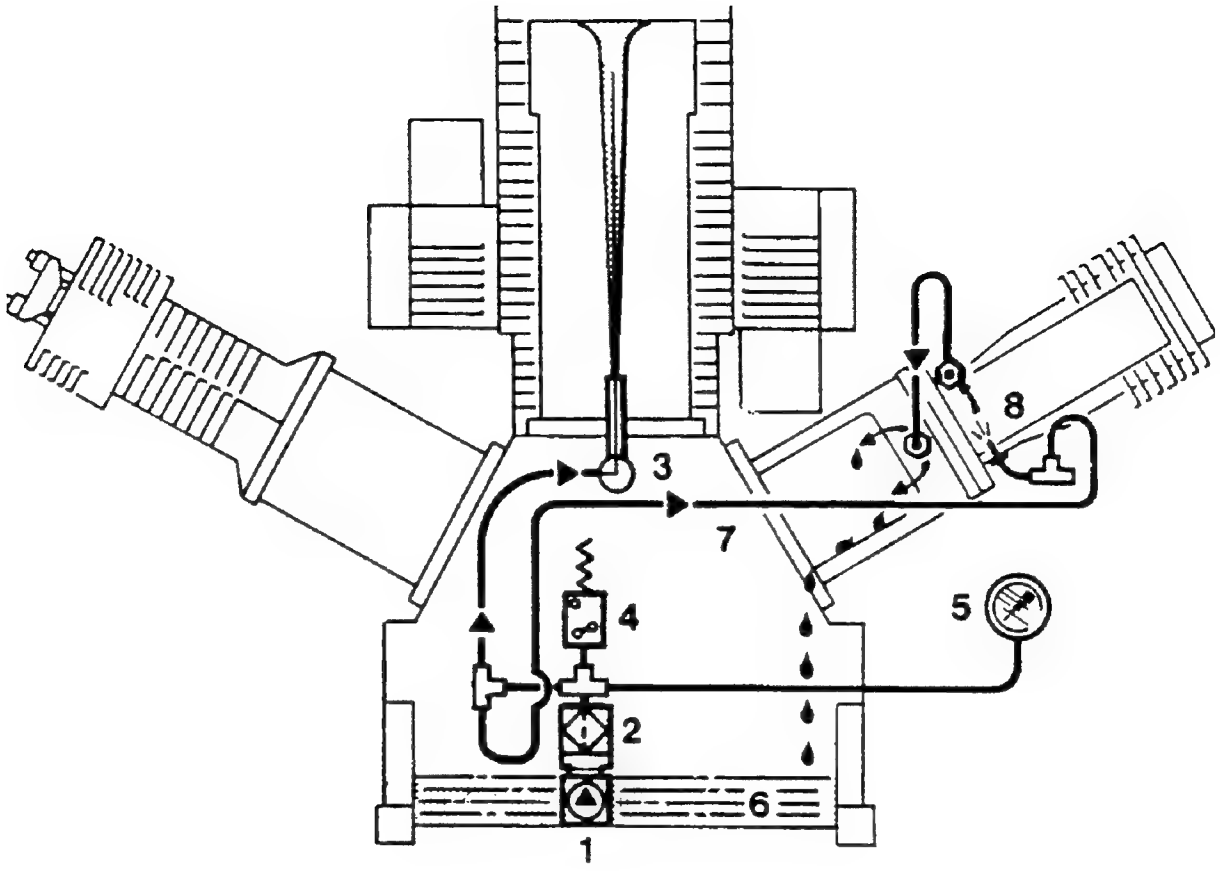
1 Cylinder 3rd stage
2 Inter-filter 2nd/3rd stage
3 Safety valve, 2nd stage
4 Inter-filter 3rd/4th stage
5 Safety valve, 3rd stage
6 Cylinder 1st/2nd stage
7 Intake filter
8 Fan-wheel

Figure 3 Model K22.0 High Pressure Air Compressor
Right Hand Side, Viewed from Flywheel



1 Fan-wheel
2 Intake filter
3 Flywheel
4 Cylinder 4th stage
5 Oil and water separator
6 Final pressure safety valve
7 3/2-way solenoid valve
8 Condensate drain valve, 4th stage
9 Condensate drain valve, 3rd stage
10 Condensate drain valve, 2nd stage
11 Manual condensate drain valve
12 Condensate manifold
13 Condensate outlet
14 Oil drain plug
15 Air outlet

Figure 4 Model K22.0 High Pressure Air Compressor
Left Hand Side, Viewed from Flywheel



1	Oil pump with regulating valve	5	Oil pressure gauge
2	Oil filter	6	Oil sump
3	Injection pipe	7	Pipe to 4th stage cylinder
4	Oil pressure switch	8	Oil jet

Figure 5 Model K22.0 High Pressure Air Compressor
Lubricating Oil Circuit

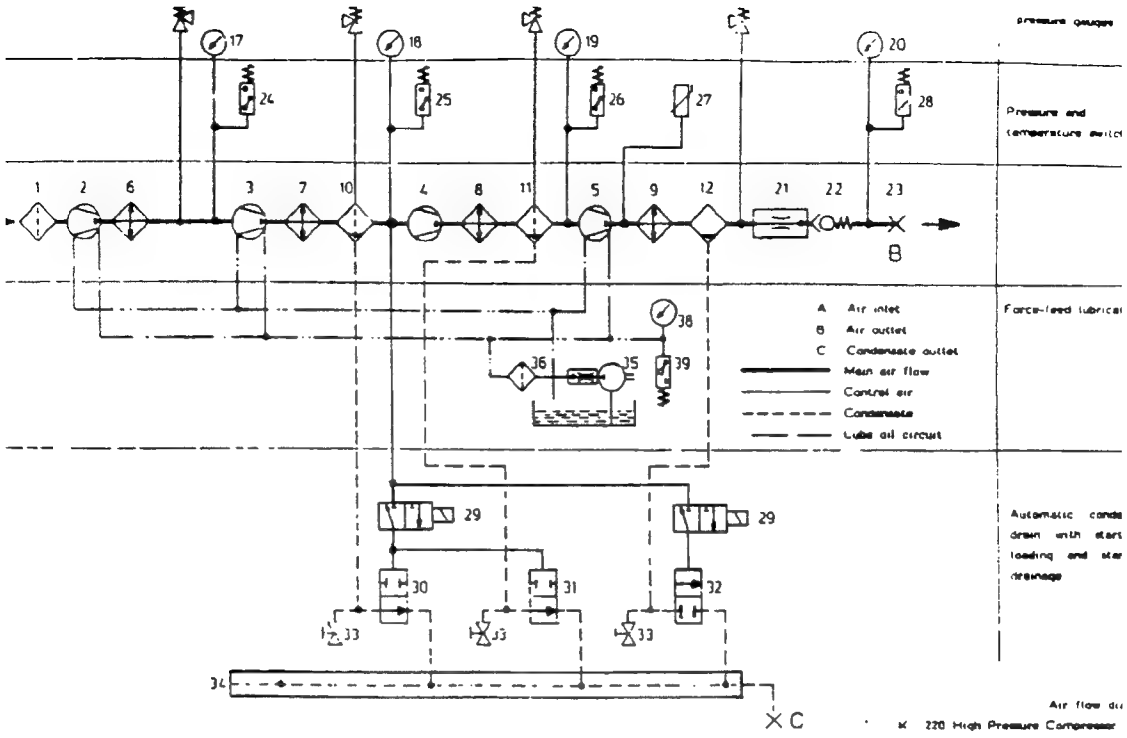
system blows down the separators at 15 minute intervals. This is accomplished by an electric timer which deactivates a solenoid valve that controls the pressure on a bank of piston type valves isolating the separators from the reservoir.

The P-10 purification system consists of a drainage separator (auto draining) and three central filter towers with replaceable cartridges. Residual oil and water vapors not drained by the auto-drain system are removed by two drying cartridges, PART No. 058825-410. The treated air is free of oil, taste and smell. Carbon monoxide is eliminated when a BAUER cartridge PART No. 058827-410 is used.

The BAUER K22.0 compressor has a capacity of 650 to 930 liters per minute (23 to 33 scfm) free air delivered at 345 bars (5,000 psi).

A pressure maintaining/non-return valve set at 150 bars (2,175 psi) is provided down-stream from the purification system. This ensures that pressure build-up occurs in the filters during start up and initial compressor air delivery. This achieves constant, optimum filtering, moisture separation, fourth stage piston ring expansion/cylinder sealing, and prevents compressed air return from the storage flasks to the compressor during unit shut down. All four stages of the compressor are protected by safety relief valves. Figure 6 provides a diagram of the compressor air flow system.

The BAUER, MODEL K22.0 comes with one BAUER Instruction Manual[7] (High Pressure Compressor Four-Stage) and one Instruction Manual and spare Parts Catalogue[8].



g. 1.5 AIR FLOW DIAGRAM

Intake filter	21 Pressure maintaining valve
Cylinder 1st stage	22 Non-return valve
Cylinder 2nd stage	23 Air outlet; connector for tube outer dia. 10 mm
Cylinder 3rd stage	
Cylinder 4th stage	24 Pressure switch, intermediate pressure 1st/2nd stage
Inter-cooler 1st/2nd stage	
Inter-cooler 2nd/3rd stage	25 Pressure switch, intermediate pressure 2nd/3rd stage
Inter-cooler 3rd/4th stage	
After-cooler	26 Pressure switch, intermediate pressure 3rd/4th stage
Inter-filter 2nd/3rd stage	
Inter-filter 3rd/4th stage	27 Temperature switch 4th stage
Oil and water separator	28 Final pressure switch.
Safety valve 1st stage	29 3/2-way solenoid valve
Safety valve 2nd stage	30 Condensate drain valve 2nd stage
Safety valve 3rd stage	31 Condensate drain valve 3rd stage
Safety valve 4th stage	32 Condensate drain valve 4th stage
Pressure gauge, intermediate pressure 1st/2nd stage	33 Manual condensate drain valve
	34 Condensate manifold
Pressure gauge, intermediate pressure 2nd/3rd stage	35 Oil pump
	36 Oil filter

Figure 6 Model K22.0 High Pressure Air Compressor
Air Flow Diagram

BAUER Instruction Manual (High Pressure Compressor Four-Stage)[7] is divided into the following sections:

1. Applicability
2. High Pressure Engineering
3. Installation and Operation
4. Service and Daily Care
5. Drainage of the Condensate

Appendix

BAUER Instruction Manual and Spare Parts Catalogue[8] is divided into the following sections:

1. General
2. Lubrication
3. Intake Filter
4. Inter-Filters
5. Oil and Water Separator
6. Pressure Maintaining And Non-Return Valve
7. Safety Valves
8. Pressure Gauges
9. Valve Heads And Valves
10. Automatic Condensate Drain
11. Electrical System
12. Compressor Drive System
13. Cooling
14. Safety Procedures
15. Installation, Operation
16. Maintenance Schedule
17. Storage
18. Repair
19. Trouble Shooting
20. Tables
21. Annex

III. TEST PROCEDURE

There are various methods of testing compressor capacities, stability, and reliability. For this compressor evaluation[3], NEDU chose to continuously run the compressor for extended periods charging a 89.2 liter (3.15 cuft) cylinder from 0 to 345 bars (0 to 5,000 psig).

The compressor and all ancillary equipment was received and set up according to manufacturer's instructions. A Cole Palmer Model 8502-14 temperature monitor and Yellow Springs Instruments 700 Series thermistor probes were attached for measuring compressor discharge and ambient temperatures. An Analox carbon monoxide monitor was used to analyze

compressor discharge air both before and after the filter purification system with the sample flow rate set at 300 ml per minute. Nitrogen with 50.8 PPM carbon monoxide was used to calibrate the high range of the monitor, and ambient air was used to set the monitor's low range at 0.

A gas mixture of 24.4% carbon monoxide and 75.6% nitrogen was injected into the compressor intake by a Victor Equipment Company manual regulator through a Fisher/Porter flow meter. Figure 7 provides a diagram of the test equipment configuration.

The introduction of carbon monoxide was adjusted to maintain approximately 50 PPM of carbon monoxide at the inlet to the central purification system. Appendix A shows the recorded data from the Test Log. The unit was operated in an exterior work area, open to ambient temperature and humidity. The testing included subjective evaluation of the system operation but did not include detailed mechanical review of the individual components of the system.

A Veeder-Root Series 6611 hand-held tachometer was used to determine compressor speed (RPM). The compressor speed was 1229 RPM.

The compressor was operated using two purification/filter cartridges and one carbon monoxide removal cartridge. A total of 25 test hours were expended. The following parameters were recorded:

1. Date
2. Time
3. Meter Test Hours
4. Ambient Temperature
5. Compressor Air Discharge Temperature
6. Ambient Humidity
7. Carbon Monoxide PPM (Before/After Filtration)
8. Injected Carbon Monoxide Flow Rate and Percentage
9. Compressor Oil Pressure
10. Compressor Final Discharge Pressure
11. Cylinder Charging Time
12. Compressor Free Air Capacity Flow Rate

Appendix A is recorded data from the Test Log.

IV. OBSERVATIONS/RECOMMENDATIONS

A. AIR DELIVERY

Compressor capacity was determined to be 1194 liters per minute (42 cfm) by calculating the average time to charge a 89.2 liter (3.15 cuft) floodable volume cylinder from 0 to 345 bars (0 to 5,000 psig). Calculations are shown in Appendix A.

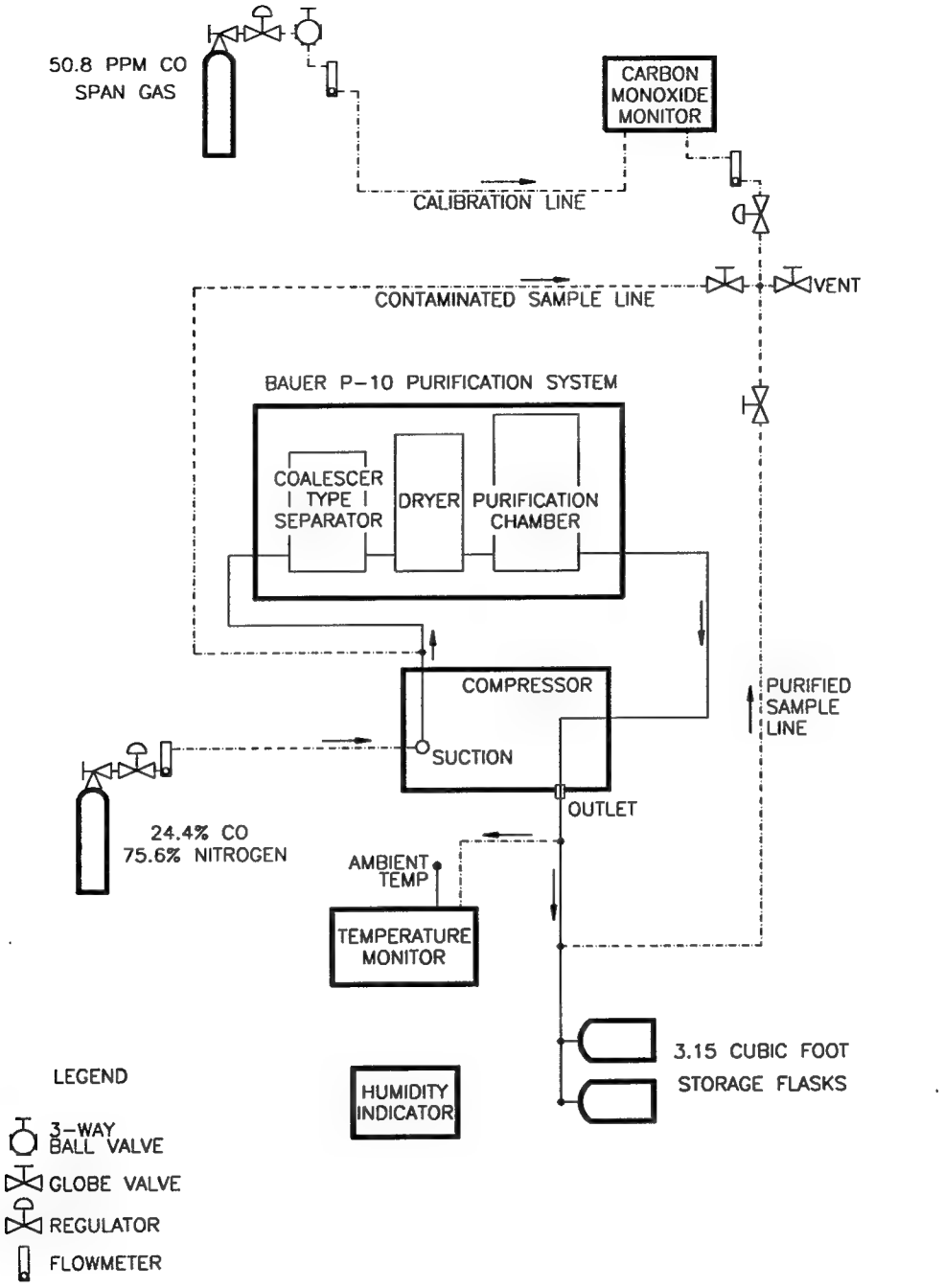


Figure 7 Test No. 94-08 Equipment Configuration

B. AIR SAMPLING

An air sample was taken from the compressor purification system discharge at 1 and 25 hours running time. The samples were sent to the Coastal System Station (CSS) Laboratory, Code 5130, for purity analysis. Analysis of air samples are listed in Appendix B.

C. OIL LUBRICATION

The oil used during the test was Navy Symbol 2190 TEP. At the beginning of the test, the compressor oil sump level indicated 3/4 full. 2190 TEP oil was added to the full mark. The oil level was checked at the beginning of each test day using the oil level dip stick. During the 25 hour testing[3], a total of 0.23 liters (1/2 pint) of oil was added to the compressor. BAUER Technical Manual[8] paragraph 2.2. states:

> *"Due to the thermal load on the compressor only high quality oil should be used. You are recommended restricting oils to those which have been approved by us and are listed in our lubricating oil list. The list is available through our technical service department."*

D. MAINTENANCE

No factory maintenance was scheduled during the 25 hours of running time.

E. PRIME MOVER

To meet Navy specifications the prime mover, if electric, should be a sealed insulation system (service A use) in accordance with MIL-M-17060 E[6], Amendment 1.

F. CADMIUM FITTINGS

General Specifications[9] state that cadmium coated fittings cannot be used in systems that exceed 400 degrees Fahrenheit or if the cadmium could come in contact with petroleum products[10]. At this time the only authorized HP compressor lubricant by the Navy is the petroleum based 2190 TEP (a petroleum based product). Recommend cadmium coated fittings be replaced with a suitable substitute.

V. CONCLUSIONS

A. The high pressure air compressor delivers air which meets U.S. Navy standards[5] at an average rate of 1194 liters per minute (42 cfm) per Appendix A. This meets the manufacturer's specification.

B. The unit is sturdy, reliable and readily maintained.

C. Based on the results of testing, the BAUER K-22.0 high pressure air compressor system recommended for inclusion on the Authorized for Navy Use List[10].

D. The vendor and NAVSEA should be contacted prior to purchase to ensure the unit meets the user's needs.

VI. REFERENCES

1. NAVSEA Task 92-002; Evaluation of Commercially Available Divers Air Compressors. Naval Sea Systems Command, 1992.

2. NAVSEA Task 92-003; Evaluation of Commercially Available Filters for H.P. and L.P. Breathing Air. Naval Sea Systems Command, 1992.

3. Bauer K-220 Electric Drive High Pressure Air Compressor and Purification System Evaluation At 5000 PSIG Test Plan 94-08 (Unmanned) (Limited Distrubution). Navy Experimental Diving Unit, February 1994.

4. Sullivan, George, Evaluation of BAUER K-220 High Pressure Breathing Air Compressor, Navy Experimental Diving Unit, NEDU TR 6-90. March 1990.

5. Naval Sea Systems Command NAVSEA 0994-LP-001-9010 U.S. Navy Diving Manual Volume 1, Rev. 3, Para 5.3.2. Air purity standards, and 6.7.2.1. Air Compressors.

6. Department of Defense MIL-M-17060 E Amendment 1, Sealed Insulated Systems, (Service A Use). Navy specification for compressor power source.

7. Bauer Instruction Manual (High Pressure Compressor Four-stage). Bauer Compressors, Inc. 1328 Azalea Garden Road Norfolk, Virginia 23502.

8. Bauer Instruction Manual And Spare Parts Catalogue (High Pressure Compressor Block). Bauer Compressors, Inc. 1328 Azalea Garden Road Norfolk, Virginia 23502 K22.0.

9. Naval Sea Systems Command. S9AA-AA-SPN-010/GENSPEC of Jan 19, 1987. General Specifications for Ships of the Navy, Cadmium Fittings.

10. Naval Sea Systems Command NAVSEAINST 10560.2C Diving Equipment Authorized for U. S. Navy Navy Use.

DATE 17 March 1994

TIME	METER HOURS	TEMPS °F		AMBI HUMID %	CO/PPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION			CYL FILL TIME	COMPRESSOR CYLINDER STAGES PSI				OIL PRESS PSI
		AMBI TEMP°F	COMP DSCHG°F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %	RATED CUFT	RATED PSI	START TIME	END TIME	END PSI		1ST	2ND	3RD	4TH	
1000	60:12	60	68	57	-	-	1.0cc	24	3.15	5,000	1014	-	-	-	45	200	945	2,200	32
1030	60:62	61	69	55	47	-	2.0cc	24	-	-	-	1041	5,000	:27	47	200	960	2,900	36
1100	61:09	65	75	54	50	8	1.6cc	24	-	-	-	-	-	-	47	200	960	2,800	36
1130	61:61	63	80	53	50	5	1.9cc	24	3.15	5,000	1157	-	-	-	47	200	1,025	3,700	36
1200	62:09	63	52	53	49	6	1.7cc	24	-	-	-	1223	5,000	:26	47	200	950	2,500	36
1230	62:62	68	83	52	50	5	1.7cc	24	-	-	-	-	-	-	47	200	1,000	3,700	36
1300	63:09	66	80	51	50	7	1.9cc	24	3.15	5,000	1314	-	-	-	47	200	950	2,800	36
1330	63:62	70	86	52	49	-	2.0cc	24	-	-	-	1340	5,000	:26	47	200	1,050	4,300	36
1400	64:09	68	79	54	51	-	1.7cc	24	-	-	-	-	-	-	47	200	950	2,700	36
1430	64:58	68	85	54	48	-	1.7cc	24	-	-	-	-	-	-	47	200	1,050	5,000	36
1445	Secured	-	-	-	50	7	1.7cc	24	-	-	-	-	-	-	-	-	-	-	-

Added one quart of oil to start test with full crankcase
Started testing (hour meter reading 60.12)
1000 Started compressor
1445 Secured testing

The mean time for pressurizing an 89.2 liter (3.15 cuft) flask from 0 to 345 bars (0 to 5,000 psi) 341.5 ATA is: $\frac{27 + 26 + 26}{3} = 26.3$ minutes. Therefore, the charging rate is: $\frac{89.2 \times 341.5}{26.3} = 1158.24$ *LPM* (40.9 *CFM*)

DATE 24 March 1994

TIME	METER HOURS	TEMPS °F		AMBI HUMID %	CO/PPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION			CYL FILL TIME	COMPRESSOR CYLINDER STAGES PSI				OIL PRESS PSI
		AMBI TEMP°F	COMP DSCHG°F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %	RATED CUFT	RATED PSI	START TIME	END TIME	END PSI		1ST	2ND	3RD	4TH	
0800	64:92	70	61	100	47	-	2.0cc	24	-	-	-	-	-	-	50	200	900	2,400	38
0830	65:34	71	78	100	49	-	1.75cc	24	3.5	5,000	0843	-	-	-	48	200	950	2,700	37
0900	65:88	72	87	100	50	7	1.75cc	24	3.5	5,000	0909	0908	5,000	:25	48	200	960	3,000	37
0930	66:39	73	92	97	46	5	1.9cc	24	-	-	-	0936	5,000	:25	48	210	1,050	4,400	38
1000	66:88	76	92	91	46	5	1.9cc	24	-	-	-	-	-	-	48	210	1,060	4,600	38
1030	67:38	77	73	90	47	6	1.9cc	24	-	-	-	-	-	-	48	200	940	2,500	38
1100	67:89	78	69	90	49	7	2.0cc	24	-	-	-	-	-	-	48	200	950	2,500	38
1130	68:38	79	92	89	50	5	2.0cc	24	-	-	-	-	-	-	48	200	960	3,000	38
1200	68:88	81	70	88	48	5	2.0cc	24	3.5	5,000	1225	-	-	-	48	200	950	2,600	38
1230	69:36	80	71	88	47	6	2.0cc	24	-	-	-	1252	5,000	:27	48	200	950	2,600	38
1300	69:85	78	72	88	49	5	2.0cc	24	-	-	-	-	-	-	48	200	950	2,600	38
1330	70:35	78	92	89	48	4	2.0cc	24	-	-	-	-	-	-	48	200	960	3,100	38
1400	70:84	77	82	92	50	5	2.0cc	24	3.5	5,000	1411	-	-	-	48	200	950	2,700	38
1430	71:35	78	91	90	50	4	2.0cc	24	-	-	-	1437	5,000	:26	48	200	1000	3,500	38
1445	Secured	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Replaced air line between condensate inter-filter 2nd/3rd stage
Checked oil level
0800 Started compressor testing
1445 Secured testing

The mean time for pressurizing an 89.2 liter (3.15cuft) flask from 0 to 345 bars (0 to 5,000 psi) 341.5 ATA is: $\frac{25 + 25 + 27 + 26}{4} = 25.75$ minutes. Therefore, the charging rate is: $\frac{89.2 \times 341.5}{25.75} = 1181.66$ *LPM* (41.7*CFM*)

DATE 29 March 1994

TIME	METER HOURS	TEMPS °F		AMBI HUMID %	CO/PPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION			CYL FILL TIME	COMPRESSOR CYLINDER STAGES PSI				OIL PRESS PSI
		AMBI TEMP°F	COMP DSCHG°F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %	RATED CUFT	RATED PSI	START TIME	END TIME	END PSI		1ST	2ND	3RD	4TH	
0705	71:61	50	50	70	50	-	2.0cc	24	-	-	-	-	-	-	48	200	910	2,400	32
0730	71:97	54	57	69	48	-	1.7cc	24	3.5	5,000	0730	-	-	-	50	210	1,050	3,100	34
0800	72:47	55	60	68	48	10	1.7cc	24	-	-	-	0800	5,000	:25	50	210	1,100	5,000	35
0830	72:94	54	60	68	50	12	1.75cc	24	3.5	5,000	0826	-	-	-	50	210	950	2,600	36
0900	73:46	57	57	63	45	13	1.75cc	24	-	-	-	0851	5,000	:25	48	210	950	2,700	36
0930	73:94	60	63	53	43	-	1.80cc	24	-	-	-	-	-	-	48	210	1,025	3,400	36
1000	74:40	60	66	56	49	-	2.0cc	24	-	-	-	-	-	-	50	210	1,080	4,500	36
1030	74:94	60	62	58	48	19	2.0cc	24	-	-	-	-	-	-	48	210	975	2,800	36
1100	75:41	64	50	59	48	17	2.0cc	24	-	-	-	-	-	-	48	210	950	2,600	36
1130	75:93	66	70	59	48	17	2.0cc	24	-	-	-	-	-	-	48	210	1,000	3,100	36
1200	76:43	68	71	59	50	15	2.0cc	24	3.5	5,000	1211	-	-	-	48	210	1,000	3,000	36
1230	76:89	65	74	59	49	16	2.0cc	24	-	-	-	1236	5,000	:25	48	210	1,000	3,200	36
1300	77:43	66	76	58	50	14	2.0cc	24	-	-	-	-	-	-	50	215	1,100	4,600	36
1330	77:92	69	76	57	48	13	2.0cc	24	-	-	-	-	-	-	50	210	1,000	2,900	36
1400	78:48	68	55	56	47	14	1.9cc	24	-	-	-	-	-	-	48	210	950	2,600	36
1430	78:89	74	74	57	49	14	1.9cc	24	-	-	-	-	-	-	48	210	960	2,700	36
1435	Secured	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

0700 Checked compressor oil level
0705 Started compressor testing
1435 Secured compressor testing

The mean time for pressurizing an 89.2 liter (3.15cuft) flask from 0 to 345 bars (0 to 5,000 psi) 341.5 ATA is: $\frac{25 + 25 + 25}{3} = 25$ minutes. Therefore, the charging rate is: $\frac{89.2 \times 341.5}{25} = 1218.47$ *LPM* (43*CFM*)

DATE 30 March 1994

TIME	METER HOURS	TEMPS °F		AMBI HUMID %	CO/PPM CONCENTRATION		CO INJECTED INTO COMP. INTAKE		CHARGED CYLINDER SIZE		CYLINDER CHARGING INFORMATION			CYL FILL TIME	COMPRESSOR CYLINDER STAGES PSI				OIL PRESS PSI
		AMBI TEMP°F	COMP DSCHG°F		BEFORE FILTER	AFTER FILTER	FLOW RATE	GAS %	RATED CUFT	RATED PSI	START TIME	END TIME	END PSI		1ST	2ND	3RD	4TH	
0642	78:99	55	50	69	50	-	2.0cc	24	-	-	-	-	-	-	48	190	900	2,600	30
0700	79:28	55	66	69	50	14	2.0cc	24	-	-	-	-	-	-	50	210	1,100	4,700	35
0730	79:77	55	70	69	50	13	2.0cc	24	-	-	-	-	-	-	50	210	1,050	3,300	36
0800	80:27	58	69	67	50	14	2.1cc	24	3.4	5,000	0810	-	-	-	48	210	975	2,800	36
0830	80:76	59	74	59	50	15	2.4cc	24	-	-	-	0835	5,000	:25	50	210	1,050	3,400	36
0900	81:26	62	68	62	50	14	2.4cc	24	-	-	-	-	-	-	48	210	950	2,700	36
0930	81:77	63	59	62	50	15	2.4cc	24	-	-	-	-	-	-	50	210	950	2,600	36
1000	82:25	64	74	62	50	17	2.4cc	24	-	-	-	-	-	-	48	210	960	2,600	36
1030	82:76	66	79	62	50	12	2.4cc	24	-	-	-	-	-	-	50	210	1,100	4,800	36
1100	83:26	67	77	60	49	12	2.4cc	24	-	-	-	-	-	-	50	210	950	3,000	36
1130	83:75	67	61	58	48	13	2.4cc	24	-	-	-	-	-	-	48	210	950	2,600	36
1200	84:26	70	84	57	48	14	2.4cc	24	-	-	-	-	-	-	50	210	1,100	4,700	36
1230	84:74	67	82	57	48	11	2.4cc	24	-	-	-	-	-	-	50	210	1,000	3,100	36
1300	85:24	68	57	56	49	12	2.4cc	24	-	-	-	-	-	-	48	210	950	2,600	36
1330	85:74	69	83	58	49	16	2.4cc	24	-	-	-	-	-	-	48	210	960	2,700	36
1345	Secured	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

0630 Checked compressor oil level
0642 Started compressor testing
1345 Secured compressor testing

The mean time for pressurizing an 89.2 liter (3.15cuft) flask from 0 to 345 bars (0 to 5,000 psi) 341.5 ATA is: 25 minutes. Therefore, the charging rate is: $\frac{89.2 \times 341.5}{25} = 1218.47$ *LPM* (43*CFM*)

Memorandum

17 March 1994

To: Dave Sullivan, NEDU

From: Glen Deason, Code 2530

Subject: Analysis of air sample from NEDU Test #94-08, Bauer K220 Evaluation. One hour sample.

1. In accordance with your request, the air sample delivered to the gas analysis lab was analyzed and found to contain:

Standard Components

Component	Level	Limit
Oxygen	21%	20-22%[2]
Nitrogen	78.1%	NONE[2]
Argon	0.9%	NONE[2]
Carbon Dioxide	53 PPM	1000 PPM[2]
Total Hydrocarbons[1]	1.5 PPM	25 PPM[2]
Carbon Monoxide	5.4 PPM	20 PPM[2]
Methane	1.5 PPM	1000 PPM[2]
Acetone	<0.1 PPM	200 PPM[2]
Benzene	<0.1 PPM	1 PPM[2]
Chloroform	<0.1 PPM	1 PPM[2]
Ethanol	<0.1 PPM	100 PPM[2]
Freon 113	<0.1 PPM	100 PPM[2]
Freon 11	<0.1 PPM	100 PPM[2]
Freon 12	<0.1 PPM	100 PPM[2]
Freon 114	<0.1 PPM	100 PPM[2]
Isopropyl Alcohol	<0.1 PPM	1 PPM[2]
Methanol	<0.1 PPM	10 PPM[2]
Methyl Chloroform	<0.1 PPM	30 PPM[2]
Methyl Ethyl Ketone	<0.1 PPM	20 PPM[2]
Methyl Isobutyl Ketone	<0.1 PPM	20 PPM[2]
Methylene Chloride	<0.1 PPM	25 PPM[2]
Toluene	<0.1 PPM	20 PPM[2]
Trimethyl Benzenes	<0.1 PPM	3 PPM[2]
Xylenes	<0.1 PPM	50 PPM[2]

Other Components

Component	Level	Limit
NONE		
C4+	<0.1 PPM	NONE

[1]Expressed as methane equivalents.
[2]Limits taken from Navy Dive Manual; Vol. 2, Rev. 3.
[3]OSHA Final Rule limits published as of July 1992 (not specified in Navy Dive Manual).

2. The above sample showed no appreciable contamination; all components were within the acceptable range.

Glen Deason
Chemist

Memorandum

31 March 1994

To: Dave Sullivan, NEDU

From: Glen Deason, Code 2530

Subject: Analysis of air sample from NEDU Test #94-08, Bauer K220 Evaluation. Twenty five hour sample.

1. In accordance with your request, the air sample delivered to the gas analysis lab was analyzed and found to contain:

Standard Components

Component	Level	Limit
Oxygen	21%	20-22%[2]
Nitrogen	78.1%	NONE[2]
Argon	0.9%	NONE[2]
Carbon Dioxide	368 PPM	1000 PPM[2]
Total Hydrocarbons[1]	1.6 PPM	25 PPM[2]
Carbon Monoxide	19.9 PPM	20 PPM[2]
Methane	1.6 PPM	1000 PPM[2]
Acetone	<0.1 PPM	200 PPM[2]
Benzene	<0.1 PPM	1 PPM[2]
Chloroform	<0.1 PPM	1 PPM[2]
Ethanol	<0.1 PPM	100 PPM[2]
Freon 113	<0.1 PPM	100 PPM[2]
Freon 11	<0.1 PPM	100 PPM[2]
Freon 12	<0.1 PPM	100 PPM[2]
Freon 114	<0.1 PPM	100 PPM[2]
Isopropyl Alcohol	<0.1 PPM	1 PPM[2]
Methanol	<0.1 PPM	10 PPM[2]
Methyl Chloroform	<0.1 PPM	30 PPM[2]
Methyl Ethyl Ketone	<0.1 PPM	20 PPM[2]
Methyl Isobutyl Ketone	<0.1 PPM	20 PPM[2]
Methylene Chloride	<0.1 PPM	25 PPM[2]
Toluene	<0.1 PPM	20 PPM[2]
Trimethyl Benzenes	<0.1 PPM	3 PPM[2]
Xylenes	<0.1 PPM	50 PPM[2]

Other Components

Component	Level	Limit
NONE		
C4+	<0.1 PPM	NONE

[1]Expressed as methane equivalents.
[2]Limits taken from Navy Dive Manual; Vol. 2, Rev. 3.
[3]OSHA Final Rule limits published as of July 1992 (not specified in Navy Dive Manual).

2. The above sample showed no appreciable contamination; all components were within the acceptable range.

Glen Deason
Chemist